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## THE MASSES AND ABSOLUTE MAGNITUDES OF VISUAL BINARIES[1]

Our knowledge of the masses of the stars is derived mainly from double stars. Altho several methods have been devised for their determination, the principal way to derive masses for individual systems without any assumptions is applicable to those visual binaries for which both the orbit and the parallax have been determined. In such cases we have

$$m_1+m_2=\frac{a^3}{\pi^3P^2},$$

in which $m_1 + m_2$ is the only unknown quantity, $a$, $\pi$, and $P$ being semi-major axis, parallax, and period, respectively.

During the last few years both the number and the quality of stellar parallaxes have been greatly improved; a new attempt is being made, therefore, to enlarge our knowledge of the masses of the stars. For the orbits of the binaries I have used the data recently published by Aitken in Table I of his book, "*The Binary Stars*"; for the parallaxes all the material now available has been employed, including unpublished spectroscopic parallaxes which Dr. Adams has kindly allowed me to use for this purpose.

Fifty-five binaries, whose orbits are known with at least fairly good approximation, have available parallaxes, and for each of these the weighted mean parallax has been determined. Modern observations, such as those by the Yerkes, McCormick, and Sproul Observatories, were given weight 1; others were assigned weights according to their probable errors. Twenty-six stars have parallaxes with weights $> 3$, sixteen have weights 2-3, and the others have weights $< 2$. In order to make the results more reliable, stars were excluded when the percentage probable error in the parallax exceeded fifty per cent in the first class, twenty-five per cent in the second, and ten per cent in the third. This process leaves thirty-nine binaries for which we may accept the parallax as at least fairly well determined.

For each system $m_1 + m_2$ and the absolute magnitude $M$ were computed. The results are given in the table, arranged according to spectral type and absolute magnitude.

For two stars the masses surpass 20 times that of the Sun; for *β Delphini* $m_1 + m_2$ is not less than 45.7, and for $\Sigma$ 1835 it is 26.1.

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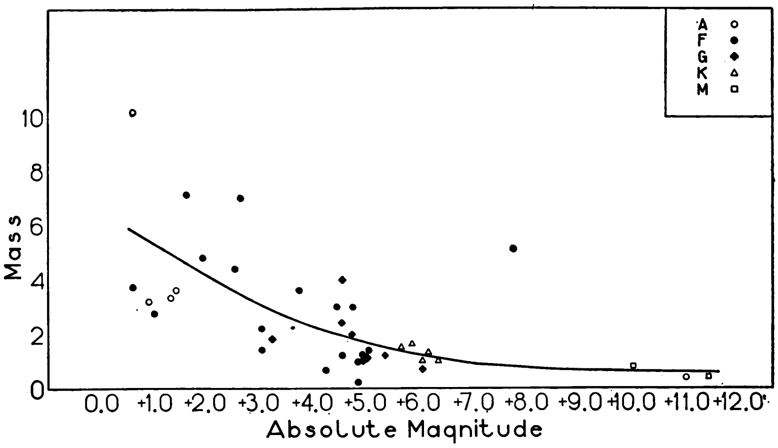
[1] Read at the Pasadena meeting of the *Ast. Soc. Pac.*, June 19, 1919.

| A | | | | F | | | | G | | | | K | | | | M | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M | Mass | w | p.e. | M | Mass | w | p.e. | M | Mass | w | p.e. | M | Mass | w | p.e. | M | Mass | w | p.e. |
| | | | | −0.1 | 45.66 | 3.2 | 27% | | | | | | | | | | | | |
| +0.6<br>+0.9 | 10.29<br>3.23 | 4.9<br>2.2 | 27%<br>4% | +0.6 | 3.76 | 5.2 | 35% | | | | | | | | | | | | |
| +1.3<br>+1.4<br>+1.6 | 3.31<br>3.61<br>26.09 | 0.7<br>4.4<br>3.0 | 1%<br>21%<br>14% | +1.0<br>+1.6<br>+1.9 | 2.77<br>7.33<br>4.87 | 3.0<br>5.0<br>5.0 | 45%<br>28%<br>18% | | | | | | | | | | | | |
| | | | | +2.5<br>+2.6 | 4.41<br>7.29 | 5.6<br>2.5 | 14%<br>8% | | | | | | | | | | | | |
| | | | | +3.0<br>+3.0<br>+3.7 | 1.37<br>2.19<br>3.60 | 3.7<br>5.0<br>4.4 | 3%<br>11%<br>14% | +3.2 | 1.65 | 4.2 | 11% | | | | | | | | |
| | | | | +4.2<br>+4.4<br>+4.5<br>+4.7<br>+4.8<br>+4.8<br>+4.9 | 0.69<br>2.95<br>1.18<br>2.94<br>0.18<br>0.90<br>1.17 | 2.0<br>2.2<br>3.4<br>3.0<br>2.0<br>3.6<br>8.3 | 10%<br>15%<br>5%<br>18%<br>18%<br>13%<br>2% | +4.5<br>+4.5<br>+4.7<br>+4.9<br>+4.9 | 4.00<br>2.38<br>2.01<br>1.17<br>1.09 | 2.0<br>5.0<br>0.5<br>3.2<br>2.0 | 16%<br>40%<br>1%<br>12%<br>8% | | | | | | | | |
| | | | | +5.0 | 1.43 | 3.2 | 16% | +5.3 | 1.22 | 3.1 | 5% | +5.6<br>+5.8 | 1.53<br>1.63 | 2.7<br>7.6 | 23%<br>3% | | | | |
| | | | | | | | | +6.0 | 0.73 | 5.1 | 10% | +6.0<br>+6.1<br>+6.3 | 0.96<br>1.34<br>1.09 | 4.2<br>2.6<br>2.7 | 6%<br>8%<br>15% | | | | |
| | | | | | | | | | | | | | | | | + 9.9 | 0.88 | 4.0 | 5% |
| +10.9 | 0.44 | 2.9 | 8% | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | +11.3 | 0.43 | 2.3 | 2% |

In the first case the parallax is found to be +0″.015 ± 0″.004, weight 3.2; for Σ 1835, $\pi = +0''.007 \pm 0''.0015$, weight 3.0. Altho for both binaries the percentage probable errors are small, the parallaxes themselves are also so small that not much weight should be attached to these results. It seems quite probable that later determinations of parallax for both stars may greatly alter the computed masses; I have therefore excluded both from the following discussion.



In the accompanying figure the masses are plotted as ordinates against the absolute magnitudes as abscissae; the correlation appears independent of spectral type. The smooth curve, based on the means of 3 and 4 stars, gives the best observational relation now obtainable between mass and absolute magnitude.

To investigate a possible relation between mass and velocity, Miss Burwell kindly furnished me the radial velocities (corrected for the Sun's motion) of 34 of the 37 systems shown in the diagram. The dispersion of the velocities for systems of about the same mass, as well as that of the masses for stars with nearly the same velocities, is so large as practically to efface any relation between these two quantities. Taking the means of eight or ten stars we find some evidence, however, that in the mean the larger masses have smaller velocities. The change in velocity is from 17 to 22 km/sec for a decrease in mean mass from 6.21 to 0.65 that of the Sun. Grouping the stars according to velocities, we find an indication that the larger velocities belong to stars with small mean masses.

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